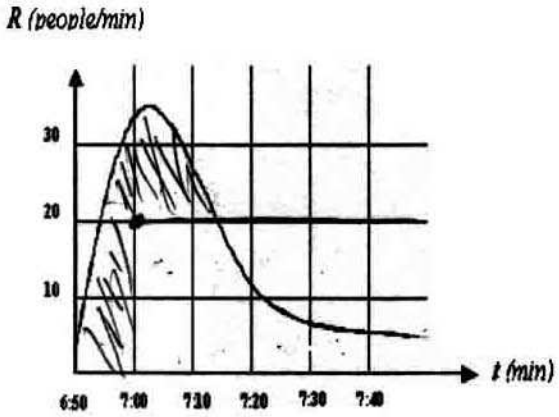

9. (14 points) On the day after Thanksgiving, the stores were mobbed with shoppers. In the local ToysWereU Store there were already 50 people in line when the security guards showed up at 6:50 a.m. The graph above shows the rate, R, in arrivals/minute at which people arrived after 6:50.

The store opens at 7:00 a.m., and the guards are to allow people into the store at a constant rate of 20 people per minute. Use this information and the graph to estimate the following:

(a) The length of the line (i.e. the number of people) at 7:00 when the guards begin letting people into the store.

$50 + 200 \approx 250$ people

(b) The length of the line at 7:20.

$$\underbrace{250}_{\text{at 7:00}} + \int_{7:00}^{7:20} R(t)\,dt - \underbrace{400}_{\text{ppl}} \approx \underbrace{250 + 500}_{750} - 400 \approx 350 \text{ ppl.}$$

(c) The rate at which the line is growing at 7:10.

$\sim 27 \frac{\text{ppl}}{\text{min}} - 20 \frac{\text{ppl}}{\text{min}} \sim 7 \frac{\text{ppl}}{\text{min}}$

(d) The length of time a person who arrives at 7:00 has to stand in line.

$\frac{250}{20} = \sim 12.5$ minutes

(e) The time at which the line disappears.

By 7:40, $\sim$ 900 ppl have arrived (including the original 50). 800 have been let into the store. The line is decreasing @ $\sim$ 15 ppl/min $\rightarrow$ So $\sim$ 7:47 the line should disappear.